KAPITEL 6 / *CHAPTER 6* [6]
OPTIMIZATION OF THE RECIPE FOR MAKING GALETTES IMPROVED WITH INNOVATIVE INGREDIENTS

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Introduction

One of the key challenges facing scientists and restaurateurs today is the development and improvement of dishes to increase their nutritional value without compromising quality. An important role in this process is played by the addition of innovative products to the classic recipe, which contributes to the achievement of the set goal. However, it is necessary to accurately determine the optimal amount of these ingredients to achieve the desired result. This task can be solved by optimizing the recipe of the dish [1-3].

The mathematical theory of optimization offers an aid that makes possible the systematic development of solutions. A prerequisite for the use of this auxiliary means is the formulation in mathematical terms of the corresponding problem, that is, the arrangement of the mathematical description for restrictions, actions and achieving the goal of the sought solutions [3,4].

Optimization theory provides ready-made decision aids that can be used after the optimization problem is formulated. However, the formalization of the translation of the verbal formulation of the problem into mathematical terms cannot be performed without applying the experience and qualifications of the problem setter [5]. Of course, knowledge of optimization methods is the main prerequisite for their rational application.

The effectiveness of optimization methods, which allow the selection of the best option without directly checking all possible options, is closely related to the wide use of achievements in the field of mathematics through the implementation of iterative calculation schemes based on strictly justified logical procedures and algorithms, based on the application of computer technology [6]. Therefore, the presentation of the methodological foundations of optimization requires the involvement of the most

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important results of matrix theory, elements of linear algebra and differential calculus, as well as the provisions of mathematical analysis.

Optimization methods are effectively used in the design and management of technological processes. When designing technological processes and productions, as well as control systems, the best production method, production scheme, technological mode, control system option are selected. When operating technological processes and productions, it is desirable to ensure the best technological mode with the help of an optimal control system [7].

In order to use the mathematical results and numerical methods of the optimization theory to solve specific problems, it is necessary to establish the boundaries of the system to be optimized, to define a quantitative criterion on the basis of which it is possible to analyze the options in order to identify the optimal one, to select the variables used to determine characteristics and identification of options, and finally, to build a model reflecting the relationships between variables. This sequence of actions makes up the content of the process of setting the optimization problem. The correct statement of the problem is the key to the success of optimization research [7,8].

The quantitative assessment of the optimized quality of the object is called the criterion of optimality. The spectrum of possible formulations of such criteria is very wide, for example, when it is necessary to minimize the duration of the product production process, maximize production rates, minimize the amount of energy consumed, maximize load, etc. Regardless of which criterion is chosen during optimization, the "best" option always corresponds to the minimum or maximum value of the characteristic indicator of the quality of system functioning. Only one criterion can be used when determining the optimum, because it is impossible to obtain a solution that simultaneously provides the solution of several problems [8].

The mathematical implementation of the optimality criterion is called the goal function or objective function. The form of the optimality criterion is determined by the specific content of the solved optimization problem and can sometimes have a significant impact on the choice of the solution method. On the basis of the selected criterion of optimality, a target function or a goal function is formed, which represents the dependence of the criterion of optimality on the parameters affecting its value.

Formulation optimization is the choice of the most effective ratio between product components to ensure its best quality. Such actions involve the selection of a specific indicator capable of confirming the effectiveness of the chosen option [8].

Materials and methods

In this work, taking into account the possibility of multivariate influence on the criterion of optimality in the experimental area, the method of mathematical and statistical planning of the full factorial experiment (FFE) was used. Such planning at this stage of research is aimed at obtaining maximum information about the recipe for obtaining products of a given quality.

The practice of FFE allows you to purposefully change the conditions of the experiment and obtain a mathematical model of the investigated process with the least expenditure of time, materials and other resources. The solution of this model will form the most effective recipe for making galettes. The main levers of planning are the optimal method of controlling the experiment, which takes into account all possible interactions affecting the criterion of optimality [8].

The least squares method was used for regression analysis.

The recipe for making galettes was chosen as the object of the research.

The subject of the study is indicators of the degree of wetting of finished products, %.

Results and discussion

To optimize the formulation of the improved product, the degree of wetting was chosen as the optimality criterion (Q).

The optimization task was to establish the optimal recipe for making galettes under the condition Q => max, %.

Determination of the degree of wetting for each experiment was carried out in three repetitions with statistical processing of the results.

Studying the methods of baking galettes, correct and effective parameters (controlling factors) were chosen, capable of changing the level of Q in the desired direction: the content of citrus pectin - q, % and the content of pumpkin powder - j, %.

We will plan the study of the influence of controlling factors on the control parameter at three levels: 1. upper; 2. middle; 3. the lower one.

Let's introduce the necessary notation: H – degree of wetting, %; content of citrus pectin - q, % content of pumpkin powder - j, %. u.l.; m.l.; l.l - upper, middle, lower levels, respectively; ±Δ – step of variation of controlling factors relative to the average; + X_1 - u.l. q; - X_1 – l.l. q, + X_2– u.l, j; -X_2– l.l., j; X_{o1}, X_{o2} - m.l. for q and j.

To create an experiment planning matrix, we plan to change the controlling factors at three levels. For X_1 – q + Δ (u.l.); q (m.l.) and q - Δ (l.l.), for X_2 – j +Δ (u.l.); j (m.l.) and j - Δ (l.l.). FFE levels are presented in Table 1.

Table 1 – Experiment planning levels

Level		**Controlling factors**	
		q, %	**j, %.**
		X_1	**X_2**
Lower	–	2,5	2,5
Middle	o	5	5
Upper	+	7,5	7,5
Variation interval	Δ	2,5	2,5

Since a matrix of two control factors **n** (q and j) is created in the planning of the experiment, at two levels of changes (u.l.; l.l.), the experiment will be carried out according to the number of sufficient experiments, which are calculated according to the equation: $N = 2^n = 2^2 = 4$ So, 4 experiments are enough to implement all possible combinations of control factors. The matrix-plan of the active experiment is shown in Table 2.

Each line of experiments (N=4) was repeated 3 times, obtaining the values of parallel experiments (m_1, m_2, m_3). The average results of H_a are summarized in Table 3.

Quantitative characteristics of the relationship between variables (H; q; j) are obtained based on the results of a regression analysis conducted using the method of least squares.

Table 2 – Matrix-plan FFE study of the influence of controlling factors on the degree of wetting of galettes

No research	Joint action of factors			
	Marking level of change factor	Number, units measurement, %	Marking level of change factor	Quantity, units measurement, %
1	$+X_1$	7,5	$+X_2$	7,5
2	$+X_1$	7,5	$-X_2$	2,5
3	$-X_1$	2,5	$+X_2$	7,5
4	$-X_1$	2,5	$-X_2$	2,5

Table 3 – Averaged results of the experiment

Experiments N	Controlling factors		Degree of wetting
	q, %	j, %	H_a, %
1	7,5	7,5	148,70
2	7,5	2,5	150,30
3	2,5	7,5	135,40
4	2,5	2,5	126,60

According to the results of the statistical analysis, the following results were obtained:

	Coefficients regression equation	Calculation errors coefficients	t-statistics
Y-intersection (H)	118,15	7,80	15,15
Changeable X_1	3,70	1,04	3,56
Changeable X_2	0,72	1,04	0,69

Multiple R	0,96
R^2	0,93
Normalized R^2	0,79
Standard error	5,20
Observation	4,00

The graphs (Figures 1 and 2) should be highlighted separately, which demonstrate the closeness of the regression lines of experimental data (Y) and calculated ones.

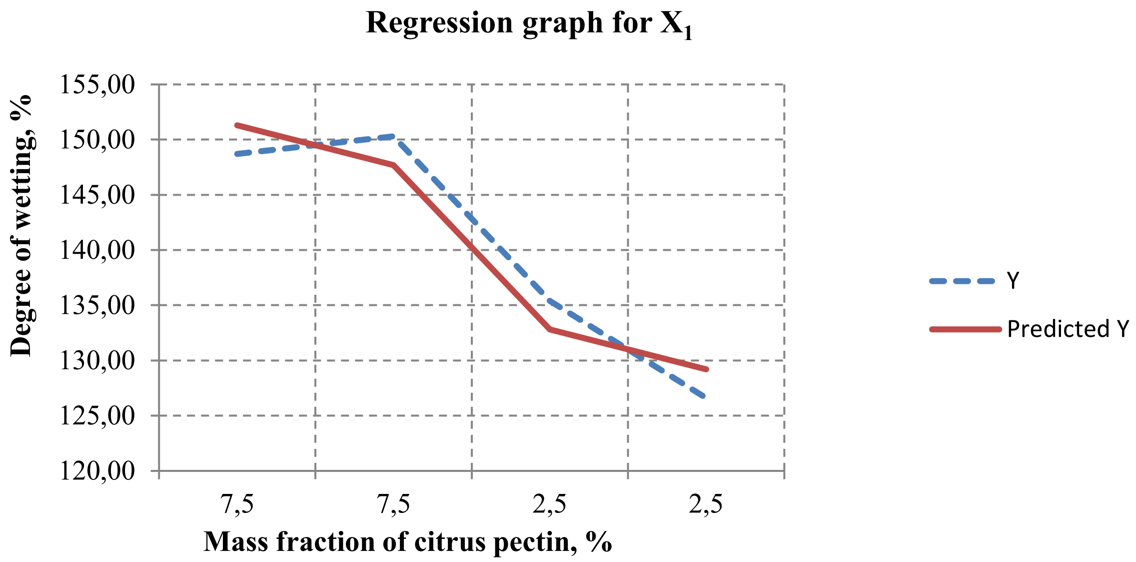

Figure 1 – Graph of approximation of experimental data for X1 – mass fraction of citrus pectin, %

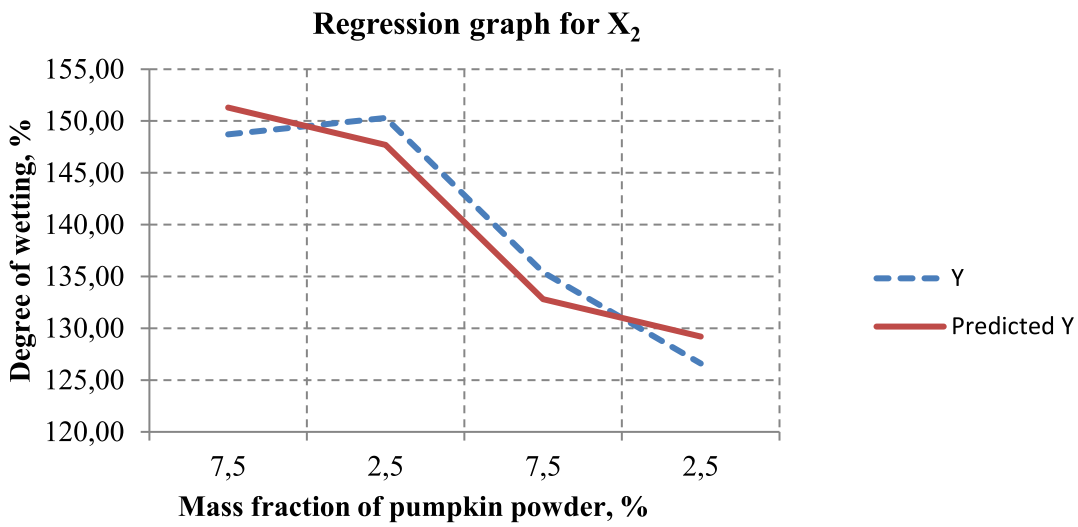

Figure 2 – Graph of approximation of experimental data for X2 – mass fraction of pumpkin powder, %

As a result of mathematical modeling of the set optimization tasks, a mathematical model was obtained:

$$\mathbf{H = 118{,}15 + 3{,}7\ X_1 + 0{,}72\ X_2}$$

The level of adequacy of the model (coefficient of determination) $R^2 = 0{,}93$ was determined. As a result, it can be stated that the obtained mathematical model is

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adequate and suitable for calculating the mathematical expectation of the optimal values of the controlling factors.

The F-statistic was used to confirm the non-random nature of the adequacy of the model.

Acting in accordance with the requirements of the analysis, the obtained results should satisfy the inequality $F_{calc}>F_{crit}$. $F_{cal}c = 6,57$; $F_{crit} = 0,27$. Based on the existing results, we can confidently say that the adequacy of the model is not accidental.

To predict the value of H from the new values of q and j that were not studied, but may be in the probable range of optimal values of Q, the statistical function "TENDENCY" in the Excel program was used.

Table 4 – Experimental and calculated data

q, %	**j, %**	**H_a**
7,5	7,5	148,70
7,5	2,5	150,30
2,5	7,5	135,40
2,5	2,5	126,60
1,5	11,5	131,98
2,5	10,5	134,96
3,5	9,5	137,94
4,5	8,5	140,92
5,5	7,5	143,9
6,5	6,5	146,88
7,5	5,5	149,86
8,5	4,5	152,84
9,5	3,5	155,82
10,5	2,5	158,8
11,5	1,5	161,78

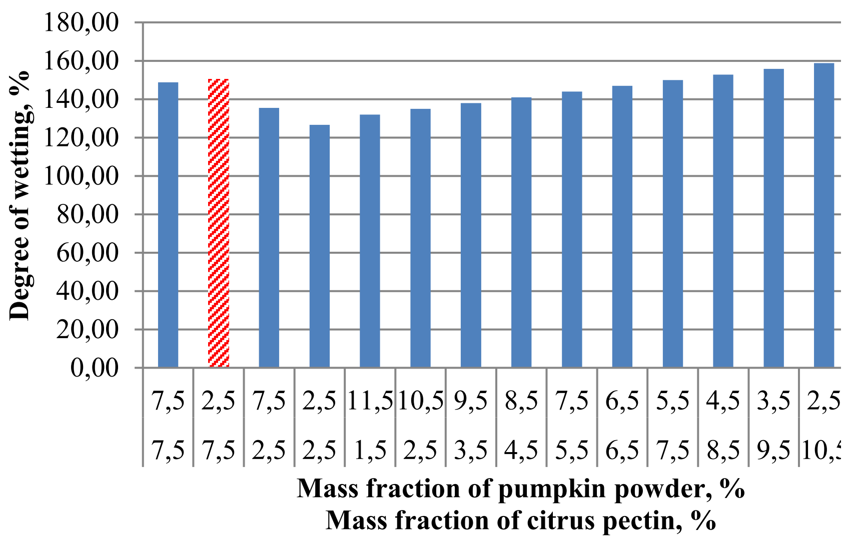

Figure 3 – Determination of the optimal recipe for making galettes

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Based on the experimental and calculated data, the chart "Determining the optimal recipe for making galettes" was constructed. For this, the experimental and calculated data were compiled in the form of Table 4.

From the obtained results of determining the optimal recipe for making galettes (Fig. 3), it follows that the optimal values for obtaining the maximum degree of wetting of galettes are the mass fraction of pectin 7.5% and the mass fraction of pumpkin powder 2.5%, since the further increase in the mass fractions of these ingredients will lead to deterioration of consumer properties of the finished product and is economically impractical.

Conclusion

Optimization allows to improve the texture, taste characteristics and organoleptic properties of galettes, which contributes to increasing consumer satisfaction. In addition, optimization helps to adapt the product to modern market needs, including requests for healthy food, reduced calorie products or products with detoxifying properties.

According to the results of the optimization of the recipe composition and technological parameters, it was established that the optimal values of the content of innovative ingredients for obtaining the maximum degree of wetting of galettes are the mass fraction of pectin 7,5% and the mass fraction of pumpkin powder 2,5%, since the further increase in the mass fractions of these ingredients will lead to deterioration of consumer properties of the finished product and is economically impractical.

In general, optimization helps to increase the quality and efficiency of production, which makes the product more competitive.

This work emphasizes the importance of optimizing food recipes in order to obtain products of the highest quality with the lowest costs of raw materials and resources used in its manufacture.

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